IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of

Friedrich Boecking

Based on PCT/DE 01/02143

For: Pressure-Controlled Double-Acting High-Pressure Injector

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Prior to examination, please amend the above-identified application as follows:

IN THE SPECIFICATION

Page 1, between the title and paragraph [0001], insert the following:

[0000.2] CROSS-REFERENCE TO RELATED APPLICATIONS

[0000.4] This application is a 35 USC 371 application of PCT/DE 01/02143 filed on June 07, 2001.

[0000.6] BACKGROUND OF THE INVENTION

Page 4, replace paragraph [0011] with the following amended paragraph:

[0011] BRIEF DESCRIPTION OF THE DRAWINGS

replace paragraph [0012] with the following amended paragraph:

[0012] The invention will be described in further detail below in conjunction with the drawings, in which:

delete paragraph [0013];

replace paragraph [0014] with the following amended paragraph:

[0014] Fig. 1 is a fragmentary longitudinal section through the injector proposed according to the invention, which achieves various injection phases;

replace paragraph [0017] with the following amended paragraph:

[0017] DESCRIPTION OF THE PREFERRED EMBODIMENTS

Page 5, replace paragraph [0019] with the following amended paragraph:

[0019] In the housing 2 of the injector 1, a control part 4 is received in a bore 3 extending substantially vertically. By means of an actuator, such as an electromagnet, a piezoelectric actuator, or a mechanical-hydraulic actuator, not shown in detail here and achieving a plurality of switching states, the control part 4 can be moved up and down in the bore 3 of the housing 2. An inlet 5 from the high-pressure collection chamber is provided in the upper region of the injector housing 2; in the region of a constriction of the control part 4, it discharges into the bore 3 in the housing 2 of the injector 1. Below the orifice of the injector 5 from the high-pressure collection chamber, a valve chamber 8 is provided in the housing 2 of the injector 1. The valve chamber 8 is embodied with a valve chamber diameter greater than the diameter 9 of a head region 6 of the control part 4 in the region of the valve chamber 8. In the head region 6 of the control part 4, control edges 36 and 37 toward the control part are embodied both on the upper end of the head region 6 and on its lower end (see the view in Fig. 2).

replace paragraph [0020] with the following amended paragraph:

[0020] The seat diameter and the guide diameter on the control part 4, which is

embodied rotationally-symmetrically to the axis of symmetry, are all embodied with the same diameter 7. As a result, the control part 4 proposed according to the invention can be designed to be force-balanced.

replace paragraph [0021] with the following amended paragraph:

[0021] From the valve chamber 8, which is configured as approximately diamond-shaped in section in the housing 2, a nozzle inlet orifice 10 branches off, connected to which is a nozzle inlet 11, which extends through the injector housing 2 and discharges into a nozzle chamber 12. The nozzle chamber 12 is provided in the front region of an injection nozzle system and with its nozzle tip 33 discharges into the combustion chamber of a direct-injection internal combustion engine.

Page 6, replace paragraph [0022] with the following amended paragraph:

[0022] The head region 6 of the control part 4, which region ends in a constriction of the control part 4, is adjoined downstream by a first slide element 13, whose diameter is equivalent to the diameter 7 in the upper region of the control part 4. The first slide element 13 is surrounded by an annular leak fuel chamber 14 extending annularly around it and embodied in the housing 2 of the injector 1. From the annular leak fuel chamber 14, a leak fuel bore branches off, discharging downstream into a leak fuel line 16. Via the leak fuel line 16, excess fuel flowing out upon nozzle relief from the high pressure can be returned to the fuel tank of the motor vehicle. Also discharging into the annular leak fuel chamber 14 is a first branch from the nozzle inlet 11, by way of which the injection nozzle system, comprising the nozzle inlet 11, nozzle chamber 12 and injection nozzle 34, can be pressure-relieved after an injection phase 41 or 42 (see Fig. 3).

replace paragraph [0023] with the following amended paragraph:

[0023] The first slide element 13 is adjoined in the axial direction of the control part 4 by a constriction, which in turn is adjoined in the end region of the control part 4 by a second slide element 21. This second slide element 21 is likewise embodied with a diameter 7 with which it is guided in the bore 3 of the housing 2 of the injector 1. The second slide element 21 is likewise surrounded toward the housing by an annular chamber 22 associated with it, which via an opening likewise communicates with the nozzle inlet line 11 in the housing 2. A sealing spring 25 is disposed below an end face 26 of the second slide element 21. The sealing spring 25, embodied as a compression spring, is received in a hollow chamber 27 in the housing 2. It is braced on one end on the bottom of the bore 3 in the housing 2, and on the other, it rests with its terminal winding on an annularly configured annular control face 26 formed by a step 28 on the second slide element 21.

replace paragraph [0024] with the following amended paragraph:

[0024] With the aid of the sealing spring 25, the control part 4, operating in at least two stages, is returned to its closing position again after a new actuation by the actuator, so that the inlet 5 from the high-pressure collection chamber is sealed off from the valve chamber 8, and the control part 4 moves upwards in the vertical direction and is placed into its seat that seals off the valve chamber 8.

Page 7, replace paragraph [0025] with the following amended paragraph:

[0025] Underneath the hollow chamber 27 received in the housing 2 of the injector 1 and separately from that hollow chamber, another hollow chamber is formed in which a spring element 31 is received. The spring element 31 received in this

hollow chamber acts upon an end face 30 of a nozzle needle 29 and presses the nozzle needle 29 into its nozzle seat 34. A pressure stage 35 is embodied on the nozzle needle 29, in the region that is surrounded by the nozzle chamber 12. When the nozzle inlet 11 is acted upon by fuel at high pressure from the valve chamber 8, the fuel at high pressure is present in the nozzle chamber 12 and causes the nozzle needle 29 to open, moving out of its nozzle seat 34, counter to the action of the spring element 31. As a result, the nozzle tip 33 moves back out of its seat 34, so that an injection quantity of fuel at high pressure can be injected into the combustion chamber of a direct-injection internal combustion engine, either during a preinjection phase, during the main injection phase, or during a postinjection phase.

Page 8, replace paragraph [0027] with the following amended paragraph:

[0027] The overlap of the stroke paths 20 and 24 at the two downstream leak fuel slide elements 13 and 21, respectively, is equivalent to the stroke of the control edges embodied on the head region 6 of the control part 4.

Page 10, replace paragraph [0035] with the following amended paragraph:

[0035] The control part 4, supported displaceably in its housing 2 in Fig. 1, is assigned a piezoelectric actuator, electromagnet or similar externally actuatable switching element, with which the control part 4 is movable up and down in its bore 3 in the housing 2 of the injector 1. For performing a preinjection 41, the control part 4 is moved vertically downward by the valve actuation unit, so that the control edge 37, embodied on the underside of the head region 6, takes its seat in the housing 2 and briefly puts the gaplike valve chamber 8, 38 in communication with the inlet 5 of

the high-pressure collection chamber. As a result, a fuel quantity corresponding to the preinjection quantity can enter the nozzle inlet 11 via the orifice 10 and thus reach the nozzle chamber 12. Upon the vertically downward-oriented motion of the control part 4, the transverse bores 15, or the further transverse bore located under them, are closed by the leak fuel slides 13 and 21 embodied in the downstream region of the control part 4, so that the nozzle inlet is sealed off from leak fuel during the preinjection phase. This assures that the metered preinjection quantity of fuel is present in the nozzle chamber 12 for performing the injection. As a result of the high pressure prevailing in the nozzle chamber, the nozzle needle 29 moves upward, counter to the spring force of the spring element 31, since the high pressure is present at the pressure stage 35 of the nozzle needle 29. Accordingly, the tip 33 of the injection nozzle is lifted from its seat 34 at the combustion chamber of a direct-injection internal combustion engine, so that fuel can be injected into the combustion chambers of a direct-injection internal combustion engine.

Page 11, replace paragraph [0038] with the following amended paragraph:

[0038] By the design according to the invention of the control part 4 and the design of the valve chamber 8 as a throttle-like gap, with suitable adaptation of the diameters 9 or outer diameters of the chamber 8, two/three-valves can be embodied on the control part 4. The design of the control part with essentially the same diameter in both the guide regions and the seat regions (diameter 7) makes it possible to design the control part 4, which is movable in the bore 3 of the injector housing 2, as force-balanced.

Page 12, insert the following new paragraph:

[0041] The foregoing relates to preferred exemplary embodiments of the invention, it being understood that other variants and embodiments thereof are possible within the spirit and scope of the invention, the latter being defined by the appended claims.

Page 13, delete “Claims” and insert --I Claim--.

IN THE CLAIMS

Please cancel claims 1-9 and add new claims 10-18.

10. An injector for injecting fuel that is at high pressure into the combustion chambers of an internal combustion engine, the injector comprising

a control part (4) guided movably in a housing (2), which control part is movable vertically up and down, actuator-actuated, in a bore (3) of the housing (2) of the injector (1),

the control part (4) being actuatable by means of an actuator element which moves the control part (4) into a position that enables the fuel delivery into a nozzle inlet (10, 11),

the valve chamber (8, 38) being opened and closed during the injection phases (41, 42) by control edges (36, 37) toward the control part, and

a pressure relief of the injection nozzle system (11, 12, 34) being effected via leak fuel slides (13, 21) embodied on the control part (4).

11. The injector of claim 10, further comprising an actuator that triggers two switching stages disposed above the control part (4).

12. The injector of claim 10, wherein, during the preinjection phase (41), the head region (6) of the control part (4) is placed in contact with a second control edge (37) on the housing (2) of the injector.

13. The injector of claim 10, wherein, during the main injection phase (42), the head region (5) of the control part (4) is placed in a middle position relative to the valve chamber (8, 38) surrounding it.

14. The injector of claim 13, further comprising a diameter graduation of the valve chamber diameter (9) to the head region diameter (6), the diameter graduation acting as a throttle and limits the flow in the middle position of the head region (6) of the control part (4) in the valve chamber (8, 38).

15. The injector of claim 10, wherein the coincidence of the stroke paths h_1, h_2 at the head region (6) of the control part (4) is equal to that of the stroke paths h_3, h_4 of the slide elements (13, 21) of the control part (4) on the downstream side.

16. The injector of claim 10, wherein the injection nozzle system (11, 12, 34), after the preinjection phase (41), is pressure-relieved to the leak fuel line (16) via an annular chamber (22) on the lower slide element (21).

17. The injector of claim 10, wherein the injection nozzle system (11, 12, 34), after the main injection phase (42), is pressure-relieved via an annular leak fuel chamber (14) provided on the upper slide element (13).

18. The injector of claim 10, wherein all the guide and seat diameters of the control part (4) have the same diameter (7), and wherein the control part (4) is force-balanced.

IN THE ABSTRACT

Please substitute the attached Abstract of the Disclosure for the abstract as originally as filed.

REMARKS

The above amendments are being made to place the application in better condition for examination.

Entry of the amendment is respectfully solicited.

Respectfully submitted,

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Page 15, replace the abstract for the following amended abstract of the disclosure:

Abstract of the Disclosure

The invention relates to an injector for injecting fuel that is at high pressure into the combustion chambers of an internal combustion engine. A control part which is movable up and down by actuator actuation is received in a bore in the housing of the injector. By means of the actuator, the control part is movable into a position that enables the fuel delivery into a nozzle inlet. The valve chamber in the housing of the injector can be opened and closed during the injection phases by control edges toward the control part, while the pressure relief of the injection system is effected via slide portions disposed on the control part.

VERSION WITH MARKINGS TO SHOW CHANGES MADE

Page 1, paragraphs [0000.2], [0000.4], and [0000.6] :

[0000.2] CROSS-REFERENCE TO RELATED APPLICATIONS

[0000.4] This application is a 35 USC 371 application of PCT/DE 01/02143 filed on June 07, 2001.

[0000.6] BACKGROUND OF THE INVENTION

Page 4, paragraphs [0011], [0012], [0013], [0014], and [0017]:

[0011] [Drawing] BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The invention will be described in further detail below in conjunction with the [drawing.] drawings, in which:

[0013] [Shown are:]

[0014] Fig. 1[, the] is a fragmentary longitudinal section through the injector proposed according to the invention, which achieves various injection phases;

[0017] [Variant Embodiments]

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Page 5, paragraph [0019], [0020], and [0021]:

[0019] In the housing 2 of the injector 1, a control part 4 is received in a bore 3 extending substantially vertically. By means of an actuator, such as an electromagnet, a piezoelectric actuator, or a mechanical-hydraulic actuator, not shown in detail here and achieving a plurality of switching states, the control part [1] 4 can be moved up and down in the bore 3 of the housing 2. An inlet 5 from the high-pressure collection

chamber is provided in the upper region of the injector housing 2; in the region of a constriction of the control part 4, it discharges into the bore 3 in the housing 2 of the injector 1. Below the orifice of the injector 5 from the high-pressure collection chamber, a valve chamber 8 is provided in the housing 2 of the injector 1. The valve chamber 8 is embodied with a valve chamber diameter [9.] <u>greater than the diameter 9 of a</u> [A] head region 6 of the control part 4 [is embodied, having a diameter] in the region of the valve chamber 8. In the head region 6 of the control part 4, control edges 36 and 37 toward the control part are embodied both on the upper end of the head region 6 and on its lower end (see the view in Fig. 2).

[0020] The seat diameter [of] <u>and</u> the guide diameter on the control part 4, which is embodied rotationally-symmetrically to the axis of symmetry, are all embodied with the same diameter 7. As a result, the control part 4 proposed according to the invention can be designed to be force-balanced.

[0021] From the valve chamber 8, which is configured as approximately diamond-shaped <u>in section</u> in the housing 2, a nozzle inlet orifice 10 branches off, connected to which is a nozzle inlet 11, which extends through the injector housing 2 and discharges into a nozzle chamber 12. The nozzle [inlet] <u>chamber</u> 12 is provided in the front region of an injection nozzle system and with its nozzle tip 33 discharges into the combustion chamber of a direct-injection internal combustion engine.

Page 6, paragraphs [0022], [0023], and [0024] :

[0022] The head region 6 of the control part 4, which region ends in a constriction of the control part 4, is adjoined downstream by a first slide element 13, whose diameter is equivalent to the diameter 7 in the upper region of the control part [7] 4. The first slide element 13 is surrounded by an annular leak fuel chamber 14 extending annularly around it and embodied in the housing 2 of the injector 1. From the annular leak fuel chamber 14, a leak fuel bore branches off, discharging downstream into a leak fuel line 16. Via the leak fuel line 16, excess fuel flowing out upon nozzle relief from the high pressure can be returned to the fuel tank of the motor vehicle. Also discharging into the annular leak fuel chamber 14 is a first branch from the nozzle inlet 11, by way of which the injection nozzle system, comprising the nozzle inlet 11, nozzle chamber 12 and injection nozzle 34, can be pressure-relieved after an injection phase 41 or 42 (see Fig. 3).

[0023] The first slide element 13 is adjoined in the axial direction of the control part 4 by a constriction, which in turn is adjoined in the end region of the control part 4 by a second slide element 21. This second slide element 21 is likewise embodied with a diameter 7 [of the control part 4,] with which it is guided in the bore 3 of the housing 2 of the injector 1. The second slide element 21 is likewise surrounded toward the housing by an annular chamber 22 associated with it, which via an opening likewise communicates with the nozzle inlet line 11 in the housing 2. A sealing spring 25 is disposed below an end face 26 of the second slide element 21. The sealing spring 25, embodied as a compression spring, is received in a hollow chamber 27 in the housing 2. It is braced on one end on the bottom of the bore 3 in the housing 2, and on the

other, it rests with its terminal winding on an annularly configured annular control face 26 formed by a step 28 on the second slide element 21.

[0024] With the aid of the sealing spring 25, the control part [3] 4, operating in at least two stages, is returned to its closing position again after a new actuation by the actuator, so that the inlet 5 from the high-pressure collection chamber is sealed off from the valve chamber 8, and the control part [3] 4 moves upwards in the vertical direction and is placed into its seat that seals off the valve chamber 8. [25 “the” hollow chamber is hard to distinguish from the hollow chamber 27.]

Page 7, paragraph [0025]:

[0025] Underneath the hollow chamber 27 received in the housing 2 of the injector 1 and separately from that hollow chamber, [a] another hollow chamber is formed in which a spring element 31 is received. The spring element 31 received in this hollow chamber acts upon an end face 30 of a nozzle needle 29 and presses the nozzle needle 29 into its nozzle seat 34. A pressure stage 35 is embodied on the nozzle needle 29, in the region that is surrounded by the nozzle chamber 12. When the nozzle inlet 11 is acted upon by fuel at high pressure from the valve chamber 8, the fuel at high pressure is present in the nozzle chamber 12 and causes the nozzle needle 29 to open, moving out of its nozzle seat 34, counter to the action of the spring element 31. As a result, the nozzle tip 33 moves back out of its seat 34, so that an injection quantity of fuel at high pressure can be injected into the combustion chamber of a direct-injection internal combustion engine, either during a preinjection phase, during the main injection phase, or during a postinjection phase.

Page 8, paragraph [0027]:

[0027] [As seen in more detail in the view of Fig. 2, the] The overlap of the stroke paths 20 and 24 at the two downstream leak fuel slide elements 13 and 21, respectively, is equivalent to the stroke of the control edges embodied on the head region 6 of the control part 4.

Page 10, paragraph [0035]:

[0035] The control part 4, supported displaceably in its housing 2 in Fig. 1, is assigned a piezoelectric actuator, electromagnet or similar externally actuatable switching element, with which the control part 4 is movable up and down in its bore 3 in the housing 2 of the injector 1. For performing a preinjection 41, the control part 4 is moved vertically downward by the valve actuation unit, so that the control edge 37, embodied on the underside of the head region 6, takes its seat in the housing 2 and briefly puts the gaplike valve chamber 8, 38 in communication with the inlet 5 of the high-pressure collection chamber. As a result, a fuel quantity corresponding to the preinjection quantity can enter the nozzle inlet 11 via the orifice 10 and thus reach the nozzle chamber 12. Upon the vertically downward-oriented motion of the control part 4, the transverse bores 15, or the further transverse bore located under them, are closed by the leak fuel slides 13 and 21 embodied in the downstream region of the control part 4, so that the nozzle inlet is sealed off from leak fuel during the preinjection phase. This assures that the metered preinjection quantity of fuel is present in the nozzle chamber 12 for performing the injection. As a result of the high pressure prevailing in the nozzle chamber, the nozzle needle 29 moves upward, counter to the spring force of the spring element 31, since the high pressure is present at the pressure stage 35 of the nozzle

needle 29. Accordingly, the tip 33 of the injection nozzle is [returned] lifted from its seat 34 at the combustion chamber of a direct-injection internal combustion engine, so that fuel can be injected into the combustion chambers of a direct-injection internal combustion engine.

Page 11, paragraph [0038]:

[0038] By the design according to the invention of the control part 4 and the design of the valve chamber 8 as a throttle-like gap, with suitable adaptation of the diameters 9 or outer diameters of the [head region 6] chamber 8, two/three-valves can be embodied on the control part 4. The design of the control part with essentially the same diameter in both the guide regions and the seat regions (diameter 7) makes it possible to design the control part 4, which is movable in the bore 3 of the injector housing 2, as force-balanced.

Page 12, insert the following new paragraph:

[0041] The foregoing relates to preferred exemplary embodiments of the invention, it being understood that other variants and embodiments thereof are possible within the spirit and scope of the invention, the latter being defined by the appended claims.

Page 15, abstract:

Abstract of the Disclosure

The invention relates to an injector for injecting fuel that is at high pressure into the combustion chambers of an internal combustion engine. A control part [(4)] which is movable up and down by actuator actuation is received in a bore [(3)] in the housing [(2)] of the injector [(1)]. By means of the actuator, the control part [(4)] is movable into a position that enables the fuel delivery into a nozzle inlet [(10, 11)]. The valve chamber [(8, 38)] in the housing [(2)] of the injector [(1)] can be opened and closed during the injection phases [(41, 42)] by control edges [(36, 37)] toward the control part, while the pressure relief of the injection system [(11, 12, 34)] is effected via slide portions [(13, 21)] disposed on the control part [(4)].

[(Fig. 1)]